REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. REPORT DATE *(DD-MM-YYYY)*	**2. REPORT TYPE**	**3. DATES COVERED** *(From - To)*
05-02-2015	Final	

4. TITLE AND SUBTITLE
Test Operations Procedure (TOP)
04-2-608 Component Substitution for Use In Master and Reference Propellants

5a. CONTRACT NUMBER

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHORS

5d. PROJECT NUMBER

5e. TASK NUMBER

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
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8. PERFORMING ORGANIZATION REPORT NUMBER
TOP 04-2-608

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
U.S. Army Test and Evaluation Command
CSTE-TM (Range Infrastructure Division)
2202 Aberdeen Boulevard
Aberdeen Proving Ground, MD 21005-5001

10. SPONSOR/MONITOR'S ACRONYM(S)

11. SPONSOR/MONITOR'S REPORT NUMBER(S)
Same as item 8

12. DISTRIBUTION/AVAILABILITY STATEMENT

Distribution Statement A. Approved for public release; distribution is unlimited.

13. SUPPLEMENTARY NOTES
Defense Technical Information Center (DTIC), AD No.:

14. ABSTRACT
The objective of this Test Operations Procedure (TOP) is to instruct personnel in the techniques of conducting and evaluating new components that will replace existing components of artillery, tank, mortar, and recoilless rifle ammunition for use in master and reference propellants.

15. SUBJECT TERMS
Component Substitution Reference Propellant Artillery Ammunition Field Artillery
Tank Mortar Recoilless Rifle Ammunition

16. SECURITY CLASSIFICATION OF:			**17. LIMITATION OF ABSTRACT**	**18. NUMBER OF PAGES**	**19a. NAME OF RESPONSIBLE PERSON**
a. REPORT	**B. ABSTRACT**	**C. THIS PAGE**			**19b. TELEPHONE NUMBER** *(include area code)*
Unclassified	Unclassified	Unclassified	SAR	22	

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U.S. ARMY TEST AND EVALUATION COMMAND
TEST OPERATIONS PROCEDURE

*Test Operations Procedure 04-2-608 5 February 2015
DTIC AD No.

COMPONENT SUBSTITUTION FOR USE IN MASTER AND REFERENCE PROPELLANTS

* Approved for public release; distribution is unlimited.

1. SCOPE.

This Test Operations Procedure (TOP) describes the procedures for firing new replacement artillery ammunition components for use in master and reference propellants and the techniques to be followed in ammunition and weapon inspection and preparation before, during, and after the firings. As discussed in this TOP, artillery ammunition includes field artillery, tank, mortar, and recoilless rifle ammunition.

1.1 Objective.

The objective of this TOP is to instruct personnel in the techniques of conducting test events and evaluating new components that will replace existing components of artillery, tank, mortar, and recoilless rifle ammunition for use in master and reference propellants.

1.2 Limitations.

None.

2. BACKGROUND.

The purpose of these firings is to determine the effect of changing a selected component (other than propellant) on the established values for a master or reference calibration set of components. When a change of any component in the calibration round is required, the following will apply:

a. If changing the subject component can be considered as possibly affecting the interior ballistics of the ammunition, then a firing is required to determine whether the new candidate component is significantly different from the old component with regard to velocity and pressure.

b. If the component change is more likely to be associated with exterior ballistic performance, such as a change in an internal projectile component or dummy fuze, then no further firing is necessary, unless the exterior ballistic performance of the calibration round is involved in the acceptance of production test lots. In this latter situation, a firing is required to compare the interior and exterior ballistic effects of the component substitution.

3. REQUIRED EQUIPMENT.

The following equipment is required for testing:

a. Appropriate meteorological equipment.

b. "Check" tube. A “Check” tube is defined as a dedicated tube that will only be used for calibration purposes.

c. Stargauge.

d. Pressure gauge (piezoelectric preferred, and/or crusher).

e. Muzzle velocity radar units.

f. Constant-temperature magazine (70 ± 2 °Fahrenheit (°F)).

g. Chamber temperature indicating equipment.

4. TEST PROCEDURES.

4.1 Preparation for Test.

4.1.1 General.

The test officer shall identify which components are being substituted and review applicable drawings.

4.1.2 Weapon.

Preparations relating to the weapon shall be as follows:

a. Obtain the appropriate “Check” tube; the word "CHECK" shall be stenciled on the tube end. If a “Check” tube is not available, a first quarter tube is acceptable. If a first quarter tube will be used, examine previous firing data for uniformity and proper level of ballistic performance. Any tube displaying abnormal performance should be replaced by a satisfactory tube. Verify that the “Check” tube is a dedicated tube that will only be used for calibration purposes.

b. Review the report of the tube that will be used to verify that the tube is serviceable. If a stargauge was not performed following the last firing event, the tube shall be stargauged as described in International Test Operations Procedure (ITOP) 03-2-802**[1].

c. Verify the tube round number to ensure that additional rounds have not been fired since the last test. If the round number is not in agreement with the last gauge report, the discrepancy shall be resolved before firing.

d. The tube shall be assembled in the same type of mount as was used for the original calibration test.

e. Record caliber, model, and serial number of recoil mechanism, gun, tube, and carriage.

4.1.3 Ammunition.

Preparation of ammunition and ammunition components shall be as follows:

** Superscript numbers correspond to Appendix B, References.

a. Take all ammunition components from the same lots used in the previous calibration firing.

b. Take all ammunition components from the same lots used in the previous calibration firing and substitute new applicable components.

c. Ensure each type of crusher gauge for a given pressure range are all from the same lot.

d. Verify that the propellant is the same as that determined in the calibration test (TOP 04-2-606A[2]). Specify lot number of test propellant.

e. Record propellant charge weight.

f. Record projectile model, lot numbers, and filler type.

g. Weigh all projectiles and record all in-flight weights.

h. Number each projectile for future correlation with the round number in the firing record.

i. Record bag type when used.

j. Record combustible case type when used.

k. Record primer model and lot number when used.

l. Record igniter, type, grade, and weight when used.

m. Record fuze model and lot numbers when used.

n. Record cartridge case model and lot numbers when used.

o. Weigh and record the weight of the cartridge case when used.

p. For any ammunition item or ammunition component, including the propellant, which is determined not to be in compliance with drawing requirements:

(1) Appropriately label the item.

(2) Segregate and hold it for disposition instructions.

NOTE: Under no circumstances shall such materiel be used without written approval from the technical authority.

4.1.4 Final Inspection.

The following final inspections shall be made during the last stage of preparation for assembly:

a. When firing fixed ammunition, check crimping machine pressure for obtaining the required bullet pull.

b. Visually check all ammunition for any defects, such as dents or other abnormalities that would prevent satisfactory functioning.

4.2 Test Conduct.

4.2.1 Pre-Firing.

The following shall be accomplished on the day of firing:

a. Provide the electronics personnel with the weapon caliber and type, the weight and model of projectile, and expected muzzle velocities.

b. Check the constant-temperature chamber to ensure that the rounds and crusher gauges, when used, have been conditioned as required (70 ± 2 °F for 24 hours).

4.2.2 Firing.

a. The following restrictions to this test shall be observed:

(1) A substitute firing test must be completed on the same day it is begun.

(2) Use a uniform rate-of-fire: approximately one round every 2 to 5 minutes.

(3) Do not allow the elapsed time between removal of the round or propelling charge from its conditioning chamber and firing to exceed 5 minutes. Minimize the time that the ammunition remains in the weapon before firing.

(4) Any interruption of firing exceeding 15 minutes will require the firing of conditioning rounds. At a minimum, three conditioning rounds should be fired.

(5) Any delay exceeding 60 minutes will require initial conditions stated in paragraph 4.2.2.1 to be repeated.

(6) Just before firing the first conditioning round, and on a 15 minute basis thereafter until the completion of firing, record meteorological data.

b. Record all applicable test data in Section 5.

4.2.2.1 Conditioning Rounds.

Fire three conditioning rounds at higher zones and seven for lower zones and record the tube round number and projectile muzzle velocity (ITOP 04-2-805[3]). This relatively large number of conditioning rounds at lower zones is required to ensure proper tube conditioning to stabilize the velocities and pressures at low zones. If data still shows velocities have not stabilized, additional conditioning rounds should be fired.

NOTE: Conditioning round velocities shall be used to provide a check on the muzzle velocity radar prior to the firing of component substitution rounds.

4.2.2.2 Substitution Rounds.

Twenty rounds each with the old and new components will be fired alternately unless there is the possibility of interaction that could affect the interior ballistic performance. This interaction could occur when the candidate component is from a different manufacturer or from the same manufacturer, with a slightly different manufacturing process or source of material. If the possibility of interaction exists, then a bracketing technique should be used for the firing as shown in Table 1.

NOTE: Rounds shall be fired for the highest velocity prescribed for the weapon propellant under test.

TABLE 1. EXAMPLE OF FIRING SEQUENCE FOR COMPONENTS SUBSTITUTION (BRACKETING METHOD)

NUMBER OF ROUNDS	TYPE OF ROUND
3 or 7	Conditioning[a]
1	Fouling (Test 1)
5	Test 1
1	Fouling (Test 2)
5	Test 2
1	Fouling (Test 1)
5	Test 1
1	Fouling (Test 2)
5	Test 2
Continue the above sequence until 20 rounds of each assembly type are fired.	
NOTES: Test 1: Rounds assembled with old components. Test 2: Rounds assembled with new candidate component. [a]Three conditioners at higher zones and seven at lower zones.	

5. DATA REQUIRED.

5.1 General Test Data.

Record/obtain the following, as applicable:

a. Propellant description sheet and whether propellant is a master, reference, or matching calibration lot.

b. Data records and identification of all ammunition components.

c. Tube caliber, model, and serial number.

d. Tube stargauge data (ITOP 03-2-802[1]), to include pre-firing inspections.

e. Model of weapon mount and serial number.

f. Chamber temperature for a minimum of 24 hours and time of day.

g. Malfunction of weapon, recoil mechanism, or component parts.

h. Visible evidence of breakdown of tube, breech, recoil mechanism, carriage, etc.

i. Crimp machine pressure, force in inch-pounds.

j. Location of test site.

k. Test weapon elevation.

l. Line-of-fire.

m. Surface meteorological data, on a 15 minute basis.

5.2 Test Round Data.

Record/obtain the following, as applicable, for each round fired:

a. Tube round number.

b. Test sample number.

c. Propellant – lot number.

d. Propellant – charge weight per increment/zone.

e. Combustible case model and lot number.

f. Bag model and lot number.

g. Cartridge case weight.

h. Projectile model and lot number.

i. Individual projectile weight and all in-flight weights.

j. Projectile seating measurement, as described in ITOP 04-2-802[4], for separate-loading rounds.

k. Noticeable defects.

l. Primer model and lot number.

m. Igniter type, grade, and weight (in ounces).

n. Fuze model and lot number.

o. Time of firing.

p. Muzzle velocity as described in ITOP 04-2-805[3] and corrected for presence of crusher gauges when used and/or nonstandard projectile weight.

q. Chamber pressure.

(1) Chamber pressure as described in ITOP 03-2-810(1)[5] and corrected for nonstandard projectile weight.

NOTE: For cannon chamber pressure measurements using pressure transducers only, two will be used.

(2) Chamber gauge pressure, as described in ITOP 03-2-810(2)[6], and corrected for presence of crusher gauges and nonstandard projectile weight.

r. Residue, if any, in cartridge, case, chamber, or bore.

s. Malfunction of weapon, recoil mechanism, or component parts.

6. PRESENTATION OF DATA.

6.1 General.

a. All data required in Section 5 will be included in the final test report. If applicable, muzzle velocity and crusher gauge pressure for all test rounds shall be corrected to standard

conditions. The corrected values for muzzle velocity and chamber pressure means and standard deviations shall be calculated for all rounds.

b. The following equations should be used for calculations:

Correction to velocity and pressures due to non standard projectile weight:

Velocity Correction (ΔV):

$$\Delta \mathrm{V} = \frac{\eta(V)(\Delta w)}{w_{std}}$$

Pressure Correction (ΔP):

$$\Delta \mathrm{P} = \frac{\eta_1(P)(\Delta w)}{w_{std}}$$

Correction to velocity and pressure due to non standard projectile weight for recoilless rifles only:

Velocity Correction (ΔV):

$$\Delta \mathrm{V} = V\sqrt{\frac{w_{measured}}{w_{std}}}$$

Pressure Correction (ΔP):

$$\Delta \mathrm{P} = P\sqrt{\frac{w_{measured}}{w_{std}}}$$

Correction to velocity and pressure due to presence of crusher gauges:

Velocity Correction (ΔV):

$$\Delta \mathrm{V} = \frac{B(V)(\Delta c)}{C}$$

Pressure Correction (ΔP):

$$\Delta \mathrm{P} = \frac{B_1(P)(\Delta c)}{C}$$

Mean (μ):

$$\mu = \frac{\sum x}{N}$$

Standard Deviation (σ):

$$\sigma = \sqrt{\frac{1}{N}\sum (x-\mu)^2}$$

Where:

η = velocity coefficient for projectile-weight variation
η_1 = pressure coefficient to account for projectile-weight variation
B = velocity coefficient for presence of crusher gauges
B_1 = pressure coefficient to account for presence of crusher gauges

NOTE: In determining the velocity and pressure coefficients/corrections, a computer program for interior ballistic solution is required. Consult your technical agency or local Calibration Coordinator.

V = average measured velocity
P = average measured pressure
Δw = change in projectile weight ($\Delta w = w_{measured} - w_{std}$)
$w_{measured}$ = measured projectile weight
w_{std} = standard projectile weight
C = chamber volume
Δc = change in chamber volume due to presence of crusher gauges
x = each value in the sample
N = the number of values (the sample size)

6.2 Criteria.

a. If the results between the old and new components are not significantly different (significance level of 5-percent), accept the new component. Additionally, applicable specification requirements shall be met. If, however, the results of the firing are statistically significantly different in velocity or pressure (or in exterior ballistic performance when applicable) between the old and new components, consider the substitution of the component as unsatisfactory. The proving ground shall determine the cause of such difference prior to acceptance of the new components or obtain a new lot as a candidate for substitution, and repeat the test procedure until a satisfactory replacement lot is obtained. If a replacement substitute component lot is unavailable, a matching calibration test (described in TOP 04-2-606A[2]) shall be conducted using the available substitute component lot. From the results of the match firings, new calibration values of charge weight, velocity, and pressure (and exterior ballistics as appropriate) shall be determined when using the new component.

b. To determine if the mean of the velocity or pressure is significantly different at the 95-percent confidence level use the following method:

(1) Two-Sample T-test for Comparing Two Means:

(a) Requirements**:** Two normally distributed but independent samples are obtained.

(b) Calculate Degrees of Freedom:

$$df = \frac{\left(\frac{\sigma_1^2}{N_1} + \frac{\sigma_2^2}{N_2}\right)^2}{\frac{\left(\frac{\sigma_1^2}{N_1}\right)^2}{N_1 + 1} + \frac{\left(\frac{\sigma_2^2}{N_2}\right)^2}{N_2 + 1}} - 2$$

(2) Look for t-critical values corresponding to the degree of freedom from the t-distribution table (Table 2).

(3) Calculate T Distribution:

$$\mathrm{T} = \frac{\mu_1 - \mu_2}{\sqrt{\frac{\sigma_1^2}{N_1} + \frac{\sigma_2^2}{N_2}}}$$

(4) Interpolate known values:

$$-t \le T \le t$$

(5) If statement is true, the data gives a high degree of confidence that the new component(s) is (are) comparable.

Where:
μ_1 = mean of sample one
μ_2 = mean of sample two
σ_1 = standard deviation of sample one
σ_2 = standard deviation of sample two
N_1 = size of sample one
N_2 = size of sample two
df = degrees of freedom

TABLE 2. t-DISTRIBUTION TABLE

cum. prob	$t_{.50}$	$t_{.75}$	$t_{.80}$	$t_{.85}$	$t_{.90}$	$t_{.95}$	$t_{.975}$	$t_{.99}$	$t_{.995}$	$t_{.999}$	$t_{.9995}$
one-tail	**0.50**	**0.25**	**0.20**	**0.15**	**0.10**	**0.05**	**0.025**	**0.01**	**0.005**	**0.001**	**0.0005**
two-tails	**1.00**	**0.50**	**0.40**	**0.30**	**0.20**	**0.10**	**0.05**	**0.02**	**0.01**	**0.002**	**0.001**
df											
1	0.000	1.000	1.376	1.963	3.078	6.314	12.71	31.82	63.66	318.31	636.62
2	0.000	0.816	1.061	1.386	1.886	2.920	4.303	6.965	9.925	22.327	31.599
3	0.000	0.765	0.978	1.250	1.638	2.353	3.182	4.541	5.841	10.215	12.924
4	0.000	0.741	0.941	1.190	1.533	2.132	2.776	3.747	4.604	7.173	8.610
5	0.000	0.727	0.920	1.156	1.476	2.015	2.571	3.365	4.032	5.893	6.869
6	0.000	0.718	0.906	1.134	1.440	1.943	2.447	3.143	3.707	5.208	5.959
7	0.000	0.711	0.896	1.119	1.415	1.895	2.365	2.998	3.499	4.785	5.408
8	0.000	0.706	0.889	1.108	1.397	1.860	2.306	2.896	3.355	4.501	5.041
9	0.000	0.703	0.883	1.100	1.383	1.833	2.262	2.821	3.250	4.297	4.781
10	0.000	0.700	0.879	1.093	1.372	1.812	2.228	2.764	3.169	4.144	4.587
11	0.000	0.697	0.876	1.088	1.363	1.796	2.201	2.718	3.106	4.025	4.437
12	0.000	0.695	0.873	1.083	1.356	1.782	2.179	2.681	3.055	3.930	4.318
13	0.000	0.694	0.870	1.079	1.350	1.771	2.160	2.650	3.012	3.852	4.221
14	0.000	0.692	0.868	1.076	1.345	1.761	2.145	2.624	2.977	3.787	4.140
15	0.000	0.691	0.866	1.074	1.341	1.753	2.131	2.602	2.947	3.733	4.073
16	0.000	0.690	0.865	1.071	1.337	1.746	2.120	2.583	2.921	3.686	4.015
17	0.000	0.689	0.863	1.069	1.333	1.740	2.110	2.567	2.898	3.646	3.965
18	0.000	0.688	0.862	1.067	1.330	1.734	2.101	2.552	2.878	3.610	3.922
19	0.000	0.688	0.861	1.066	1.328	1.729	2.093	2.539	2.861	3.579	3.883
20	0.000	0.687	0.860	1.064	1.325	1.725	2.086	2.528	2.845	3.552	3.850
21	0.000	0.686	0.859	1.063	1.323	1.721	2.080	2.518	2.831	3.527	3.819
22	0.000	0.686	0.858	1.061	1.321	1.717	2.074	2.508	2.819	3.505	3.792
23	0.000	0.685	0.858	1.060	1.319	1.714	2.069	2.500	2.807	3.485	3.768
24	0.000	0.685	0.857	1.059	1.318	1.711	2.064	2.492	2.797	3.467	3.745
25	0.000	0.684	0.856	1.058	1.316	1.708	2.060	2.485	2.787	3.450	3.725
26	0.000	0.684	0.856	1.058	1.315	1.706	2.056	2.479	2.779	3.435	3.707
27	0.000	0.684	0.855	1.057	1.314	1.703	2.052	2.473	2.771	3.421	3.690
28	0.000	0.683	0.855	1.056	1.313	1.701	2.048	2.467	2.763	3.408	3.674
29	0.000	0.683	0.854	1.055	1.311	1.699	2.045	2.462	2.756	3.396	3.659
30	0.000	0.683	0.854	1.055	1.310	1.697	2.042	2.457	2.750	3.385	3.646
40	0.000	0.681	0.851	1.050	1.303	1.684	2.021	2.423	2.704	3.307	3.551
60	0.000	0.679	0.848	1.045	1.296	1.671	2.000	2.390	2.660	3.232	3.460
80	0.000	0.678	0.846	1.043	1.292	1.664	1.990	2.374	2.639	3.195	3.416
100	0.000	0.677	0.845	1.042	1.290	1.660	1.984	2.364	2.626	3.174	3.390
1000	0.000	0.675	0.842	1.037	1.282	1.646	1.962	2.330	2.581	3.098	3.300
z	0.000	0.674	0.842	1.036	1.282	1.645	1.960	2.326	2.576	3.090	3.291
	0%	50%	60%	70%	80%	90%	95%	98%	99%	99.8%	99.9%
	Confidence Level										

c. To determine if the variance or standard deviation of the velocity is significantly different at the 95-percent confidence level use the following method:

(1) Testing the Difference Between Two Variances or Standard Deviations:

(a) Requirements: Two normally distributed but independent samples are obtained.

(b) Calculate Degrees of Freedom:

$$df_1 = N_1\text{-}1$$

$$df_2 = N_2\text{-}1$$

(c) Find the upper critical values corresponding to the degree of freedom from the f-distribution table (Table 3).

$$F_{upper,df_1,df_2}$$

(d) Calculate Lower Critical Value:

$$F_{lower,df_1,df_2} = \frac{1}{F_{upper,df_2,df_1}}$$

(e) Calculate F distribution:

$$F = \frac{\sigma_1^2}{\sigma_2^2}$$

(f) Interpolate known values:

$$F_{lower} \leq F \leq F_{upper}$$

(2) If statement is true, there is not enough evidence to say that the standard deviation from sample one is different from sample two.

Where:
σ_1 = standard deviation of sample one
σ_2 = standard deviation of sample two
N_1 = size of sample one
N_2 = size of sample two
df_1 = degrees of freedom of sample one
df_2 = degrees of freedom of sample two

TABLE 3. F DISTRIBUTION TABLE: CRITICAL VALUES OF F (5% SIGNIFICANCE LEVEL) (α/2 TWO-SIDED TEST)

F Distribution for alpha = 0.025

	Degrees of Freedom of the numerator df1									
df2	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
1	647.7931	799.4822	864.1509	899.5994	921.8347	937.1142	948.2028	956.6429	963.2786	968.6337
2	38.50619	39.00004	39.16557	39.24833	39.29836	39.3311	39.35565	39.37294	39.38658	39.3984
3	17.44343	16.04417	15.43913	15.10102	14.88479	14.73472	14.62445	14.53986	14.47302	14.4189
4	12.21792	10.64905	9.979203	9.604491	9.364499	9.197265	9.074142	8.979555	8.904635	8.843926
5	10.00694	8.433631	7.76356	7.387882	7.146355	6.9777	6.853043	6.757205	6.681034	6.619189
6	8.813117	7.259871	6.598782	6.22714	5.987545	5.819743	5.695483	5.599645	5.523418	5.461345
7	8.072675	6.541541	5.889831	5.522594	5.285244	5.118579	4.994888	4.899334	4.823221	4.761119
8	7.570861	6.059452	5.415984	5.052641	4.817281	4.651696	4.528545	4.433275	4.357219	4.295117
9	7.20928	5.714696	5.078107	4.718061	4.484406	4.31973	4.197034	4.101963	4.025992	3.963862
10	6.936716	5.4564	4.825608	4.468347	4.236085	4.07212	3.949822	3.854893	3.77895	3.716792
11	6.724122	5.255885	4.63001	4.27508	4.044011	3.880643	3.758629	3.663814	3.5879	3.52567
12	6.553762	5.09587	4.474202	4.121205	3.891131	3.728303	3.606516	3.511786	3.435844	3.373543
13	6.414268	4.965273	4.347186	3.995893	3.766672	3.604256	3.482668	3.387981	3.312039	3.249667
14	6.29791	4.856702	4.241713	3.891927	3.663416	3.501356	3.379938	3.285294	3.209294	3.146852
15	6.199514	4.765042	4.15281	3.804274	3.576417	3.414669	3.293366	3.198735	3.122707	3.060194
16	6.115101	4.686683	4.07681	3.729411	3.502123	3.340631	3.219441	3.124825	3.048754	2.986155
17	6.042001	4.618869	4.011156	3.664752	3.437947	3.276682	3.155577	3.060975	2.984862	2.922192
18	5.978052	4.559666	3.953858	3.608335	3.38197	3.220919	3.099871	3.005269	2.929113	2.866372
19	5.921606	4.507513	3.903438	3.558711	3.332715	3.171849	3.050872	2.956256	2.880057	2.817245
20	5.87147	4.461242	3.858702	3.514685	3.28906	3.128349	3.007415	2.912799	2.836543	2.773675

F Distribution for alpha = 0.025

	Degrees of Freedom of the numerator df1									
df2	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
1	973.0284	976.7246	979.8387	982.5453	984.8736	986.9109	988.7153	990.3451	991.8003	993.0809
2	39.40659	39.41477	39.42114	39.4266	39.43114	39.43569	39.43933	39.44206	39.44569	39.44751
3	14.37411	14.33659	14.30453	14.27679	14.25269	14.23155	14.21267	14.19608	14.18084	14.16743
4	8.793563	8.751158	8.715006	8.683742	8.656571	8.632583	8.611323	8.592338	8.575284	8.559937
5	6.567802	6.524544	6.487596	6.455593	6.42774	6.403184	6.381356	6.361915	6.344408	6.328548
6	5.40976	5.366246	5.329014	5.296812	5.268646	5.243862	5.221807	5.202139	5.184404	5.168403
7	4.709477	4.665822	4.628475	4.596075	4.567795	4.542812	4.520643	4.500777	4.482899	4.466756
8	4.243418	4.199677	4.16216	4.129674	4.101224	4.076099	4.05376	4.033751	4.01576	3.999446
9	3.912078	3.868223	3.830593	3.797965	3.769344	3.744105	3.721624	3.701473	3.68334	3.666912
10	3.664923	3.620954	3.583182	3.550412	3.521677	3.496268	3.473644	3.45338	3.435105	3.418535
11	3.473701	3.429619	3.391733	3.358821	3.329944	3.304393	3.281642	3.261235	3.242832	3.226148
12	3.321475	3.277279	3.239265	3.20621	3.177206	3.151527	3.128633	3.108113	3.089582	3.07277
13	3.197499	3.153175	3.115034	3.081851	3.052719	3.026912	3.00389	2.983242	2.964583	2.947672
14	3.094584	3.050161	3.011891	2.978595	2.949321	2.9234	2.900265	2.879489	2.860716	2.843692
15	3.007827	2.963276	2.924907	2.891483	2.862095	2.836046	2.812797	2.791907	2.773035	2.755897
16	2.933703	2.889053	2.850555	2.817018	2.787516	2.761354	2.738005	2.717002	2.69803	2.680792
17	2.869641	2.824891	2.786294	2.752643	2.723027	2.696765	2.673303	2.6522	2.633129	2.615799
18	2.813735	2.768886	2.730189	2.696424	2.666724	2.640348	2.616787	2.595598	2.576428	2.559005
19	2.764523	2.719574	2.680778	2.646928	2.617114	2.590653	2.566992	2.545704	2.526448	2.508941
20	2.720867	2.675833	2.636938	2.603002	2.573103	2.546543	2.522789	2.501416	2.482075	2.464489

APPENDIX A. ABBREVIATIONS.

F	Fahrenheit
ITOP	International Test Operations Procedure
TOP	Test Operations Procedure

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APPENDIX B. REFERENCES.

1. ITOP 03-2-802, Measurement and Inspection of Gun Tubes.
2. TOP 04-2-606A, Establishment of Master and Reference Calibration Rounds.
3. ITOP 04-2-805, Projectile Velocity and Time-Of-Flight Measurements.
4. ITOP 04-2-802, Projectile Seating and Fallback.
5. ITOP 03-2-810(1), Electrical Measurement of Weapon Chamber Pressure.
6. ITOP 03-2-810(2), Copper Crusher Measurement of Weapon Chamber Pressure.

NOTE: The latest version of the reference documents will be used.

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APPENDIX C. APPROVAL AUTHORITY.

CSTE-TM 5 February 2015

MEMORANDUM FOR

Commanders, All Test Centers
Technical Directors, All Test Centers
Directors, U.S. Army Evaluation Center
Commander, U.S. Army Operational Test Command

SUBJECT: Test Operations Procedure (TOP) 04-2-608, Component Substitution for Use in Master and Reference Propellants, Approved for Publication

1. TOP 04-2-608, Component Substitution for Use in Master and Reference Propellants, has been reviewed by the U.S. Army Test and Evaluation Command (ATEC) Test Centers, the U.S. Army Operational Test Command, and the U.S. Army Evaluation Center. All comments received during the formal coordination period have been adjudicated by the preparing agency. The scope of the document is as follows:

This TOP describes the procedures for firing new replacement artillery ammunition components for use in master and reference propellants, and the techniques to be followed in ammunition and weapon inspection and preparation before, during, and after the firings. As discussed in this TOP, artillery ammunition includes field artillery, tank, mortar, and recoilless rifle ammunition.

2. This document is approved for publication and has been posted to the Reference Library of the ATEC Vision Digital Library System (VDLS). The VDLS website can be accessed at https://vdls.atc.army.mil/.

3. Comments, suggestions, or questions on this document should be addressed to U.S. Army Test and Evaluation Command (CSTE-TM), 2202 Aberdeen Boulevard-Third Floor, Aberdeen Proving Ground, MD 21005-5001; or e-mailed to usarmy.apg.atec.mbx.atec-standards@mail.mil.

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MICHAEL J. ZWIEBEL
Director, Test Management Directorate (G9)

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Forward comments, recommended changes, or any pertinent data which may be of use in improving this publication to the following address: Range Infrastructure Division (CSTE-TM), U.S. Army Test and Evaluation Command, 2202 Aberdeen Boulevard, Aberdeen Proving Ground, Maryland 21005-5001. Technical information may be obtained from the preparing activity: Munitions and Weapons Division, U.S. Army Yuma Proving Ground, Yuma, Arizona 85365. Additional copies can be requested through the following website: http://www.atec.army.mil/publications/topsindex.aspx, or through the Defense Technical Information Center, 8725 John J. Kingman Rd., STE 0944, Fort Belvoir, VA 22060-6218. This document is identified by the accession number (AD No.) printed on the first page.